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A SERIES OF LANTERN SLIDES OF PHOTOMICROGRAPHS AND PHOTOMICROGRAPHIC APPARATUS.

A. Clifford Mercer, M. D., F. R. M. S.

In the Journal of the Royal Microscopical Society for June, 1892, p. 305, will be found an account of a series of seventy-three lantern slides exhibited before the Royal Society March 16. The same slides, with explanations, were shown at Rochester, and the following is an abstract by the Secretary of the paper, which was illustrated with several plates not copied here.

The series consisted of three classes of photomicrographs—natural objects, printed and written matters, and apparatus. The objectives used were a Spencer $\frac{1}{25}$, a Wales $\frac{1}{8}$ and $1\frac{1}{2}$ inch, and several by Powell and Lealand. In no instance was an apochromatic used and only once an eye-piece. The Spencer $\frac{1}{25}$ has a collar adjustment for water, glycerine, and homogeneous immersion, with or without a cover-glass. The Wales objectives are corrected spherically for the violet ray. The violet image is therefore superior to the visual, with which, however, it is coincident, and the fields of these objectives are unusually flat.

The light, with two exceptions, was from the edge of a lamp flame passed through a bull's-eye, a cell containing a solution of ammonia-sulphate of copper, and substage condensers varying in adjustment. Sunlight was used in photographing two *Amphipleura*. Some of these lantern-slides have covers cemented on with dammar, and, by having but two reflecting surfaces instead of four, absorb less light and thus show brighter.

Of the slides of natural objects, nine show a mooted point in *Podura* scale structure. Three slides show broken or folded hairy wings or skin of insects, with hairs projecting from the broken or folded edge, which can be compared with the broken or folded edge of *Podura* scales shown on four slides. There are no pieces of spines or featherlets; neither do any such appear to project into the adjacent field from the edges of the *Podura* scales. If it were possible to stain *Podura* scales and cut sections of them, this question might be set at rest.

The views of printed and written objects included an ordinary newspaper, a postage stamp, and a number of pen-and-ink crossings. If one pen-and ink line cross another freshly made, the crossing will be indistinguishable, one line flowing freely into the other; but if the first be thoroughly dry, there is no more tendency for the ink to spread at the crossing than elsewhere. Pencil lines covered with ink show bits of graphite at the sides of the lines. Lines shaded after they are written and the ink is dry show the shading stroke as distinct as if on a fresh surface. In the case of Lewis *vs.* Knapp (supreme court of New York) the endorser refused to redeem the note because he had not received notice of protest, and claimed that the words "or bearer" had been erased subsequent to making the note. The other side contended that these words were erased when the note was made. Chemistry, as applied at Cornell University, could only say that the ink of the note as a whole and that of the erasure was the same.

An examination of the letter "*a*" in "bearer" showed the lines of erasure had overflowed the lines of the letter; hence the erasure must have been made before the letter was dry; but opposing counsel insisted on having the time of erasure more definitely fixed. There were 52 possible overflowings in the words "or bearer," and there were 28 as great or greater than a certain overflowing taken as a standard unit—that is, 54 per cent. The words "or bearer" were written and crossed at different intervals of time. One series at five hours gave no overflowing, and the same result was given by other series until the interval diminished to five minutes, which gave 8 per cent.; then three minutes, 4 per cent.; two minutes 1.1 per cent.; one minute, 17 per cent., half a minute, 35 per cent., and a few seconds, 90 per cent. Hence it was reasonable to believe the erasure was made within half a minute after the note was written, and the case was decided in accordance with the testimony of the microscope.

Fig. 35 shows the general arrangement of my apparatus, having one leg at one end of the bed and three at the other. The microscope is a Powell and Lealand No. 3, and the camera has a bellows, and takes plates up to 8 x 10. The camera front moves freely toward the microscope, the tube of the latter entering the lens hole in the front board of the camera till stopped by a black card fitted light tight on the end of the microscope tube. The camera front

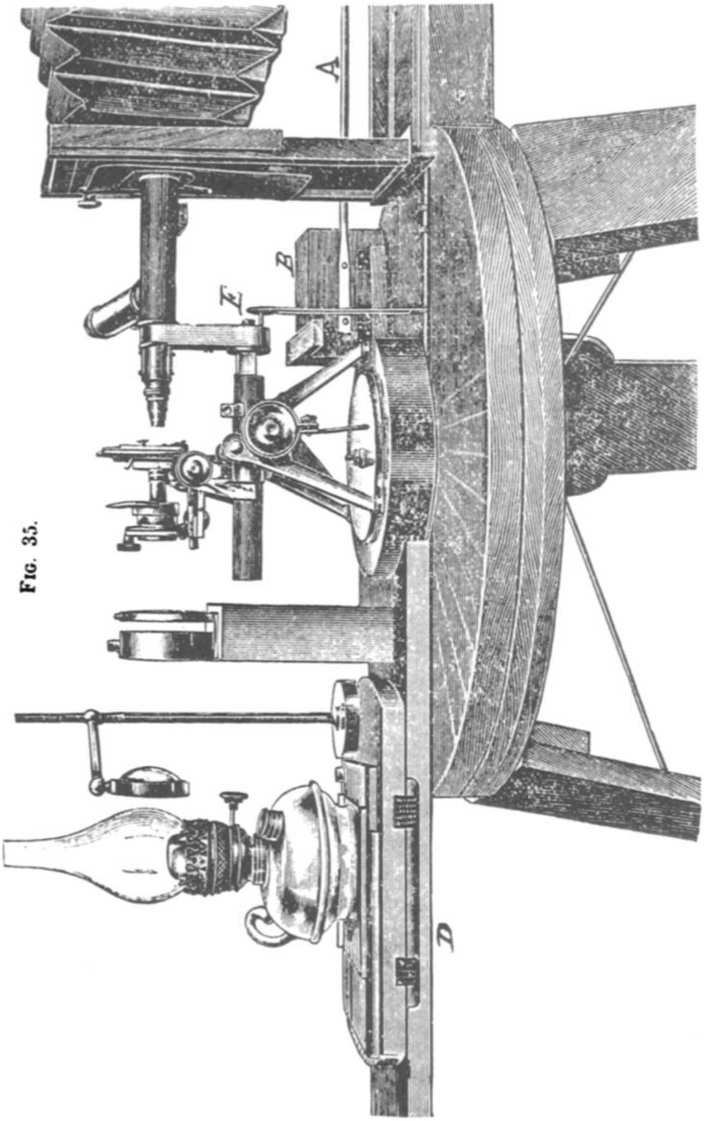

Fig. 35.

is easily slided back, so the eye can glance through the microscope without changing the position of the instrument, or the microscope and all the apparatus for lighting can be turned to one side and then turned back again by means of a board which carries them and revolves around a vertical line passing through the object on the stage. I prefer, however, to have the camera and microscope constantly connected and to use a secondary horizontal tube, shown at C. A plane mirror, silvered and polished on its objective surface, reflects the rays into the side tube, whose eye-piece is ten inches central measurement, through both tubes from the objective. When the arrangement of the object is satisfactory the mirror is withdrawn wholly into the side tube. The microscope tube, in addition to having its inner surface well blackened, has diaphragms enough to thoroughly prevent internal reflection. When an eye-piece is not used, a dummy eye-piece, without lenses but with diaphragms, is inserted to prevent reflection from the eye-end of the tube, where it is always more or less bright. I have found this dummy eye-piece a matter of importance, and think the neglect of the bright surfaces it should cover the cause of many poor results.

In Fig. 35 B is a block of hard wood sliding between cleats screwed to the table-top expansion, and on cloth bearings, moved back and forth by the brass rod A which extends to the end of the camera bed. This block carries a small wooden bar projecting over toward the microscope, and with a screw-eye on its end. Into this screw-eye drops one end of a rod (not shown), the other end of which is clamped to the milled head of the coarse adjustment. By this means coarse focusing can be done on the ground glass at any distance from the microscope by moving the rod, and with it the block and lever on the milled head.

The fine adjustment screw has a groove on its milled head, E, over which a cord runs down and about a pulley wheel, actuated by a brass rod supported all along under the camera bed, so that fine focusing can be done any distance from the microscope. Coarse focusing is done on the ground glass; fine focusing by a focusing lens held against a piece of polished plate-glass, substituted for the ground glass. Projecting from the sliding block is a second bar (not shown), ending in a screw-eye which receives a lever from the rack and pinion moving the draw-tube. Either lever is quickly fastened or loosened by a thumb-screw closing or opening the ring about the milled head. First one or the other is used; never both at once.

The draw-tube lever is used when by the Woodward method* the back focus of an objective is extended by an achromatic meniscus screwed into the objective end of the draw-tube. It seems to be almost forgotten that Dr. Woodward produced his famous photomicrographs by this method. The method, briefly, is first to arrange the object and illumination, to adjust the objective-collar most carefully for the 10-inch distance, then to remove the eye-piece, to screw the meniscus into the objective end of the draw-tube, and, finally, to adjust the draw-tube until the meniscus is at the right distance from the back of the objective to extend the focus to the ground glass, the objective meantime remaining undisturbed in its best condition. No other method gave as good results until the apochromatic method was introduced. In the apochromatic method, however, the objective is not left undisturbed, and the projecting eye-piece has two lenses with four reflecting surfaces. If it were practicable to make a compensating concave with only two reflecting surfaces, analogous to the Woodward meniscus, to be used instead of the projecting eye-piece, a so modified apochromatic method would be more rapid and might perhaps give even more brilliant results.

The lamp, edge of the flame on, and bull's-eye are carefully centered on sliding boards, so as to be able conveniently to use Mr. Nelson's method of illumination.† The light (Fig. 35) passes through an alum or water cell, and an ammonio-sulphate of copper cell—seen between the bull's-eye and substage condenser—to eliminate most of the heat rays, to give visually monochromatic light, and to make the visual image approximately the same as the actinic image. I believe by using the blue cell I have been able to approximately focus the actinic rays, for I have used very various objectives with the blue cell and have not once noticed a want of coincidence of visual and actinic foci; further, I have focused with lamplight not passing through the blue cell, and then photographed with the blue cell in place, with a result quite inferior to the next, the next being obtained under the same conditions, excepting that the blue cell was in place when focusing. The use of the blue cell in focusing secures excellent results with the Wales photo-objectives, corrected for the violet ray. After passing through the blue cell the light is received by a substage condenser and focused on the object.

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*Journal Roy. Mic. Soc., 1879, p. 664.

†Op. cit., 1885, p. 713.

My substage not only carries ordinary Powell and Lealand achromatic condensers for high-power work, but by means of adapters also carries, instead, an eye-piece or a suitable objective as a condenser for low-power work.

The round table-top expansion is divided by degree markings, enabling me to turn the board, D, supporting the lighting apparatus to any required angle for oblique illumination of transparent objects, or so far around as to cause the light to fall at suitable angles on opaque objects. That end of the revolving board which is under the microscope is circular. The upper surface of the circular portion presents two levels, a central circular higher level surrounded by a peripheral lower level. On the latter rest the three feet of the microscope tripod, in such fashion that when the two feet away from the camera or under the substage are snugly against the edge of the central raised level the object on the stage is in the vertical axis about which the board revolves. Therefore, after the board has been turned out of line for oblique illumination, the microscope can be placed in new correct position immediately by bringing the two feet mentioned against the edge of the higher level and the eye end of the axial tube to the center of the camera front. In photomicrographing an opaque object a diaphragm cap is slipped over the front of the objective. Thus a diaphragm comes to be supported about half-way between the object and the objective; it there cuts off all rays from the object or stage outside the area to be photographed, and is analogous to the hood of a portrait or landscape lens. When an objective has a short working distance, a piece of dead-black card or paper with a central hole, instead of the cap, covers all the object except the area to be photographed. In photomicrography, as in all critical optical work, it is important here and everywhere to shut out or suppress, so far as possible, every non-effective or wandering ray of light. The wainscoting of my room is black; the woodwork of the apparatus is black; the walls and floor are non-actinic; by day I always photomicrograph with covered windows, and at night I have no light in the room but that on the revolving board.

Fig. 38 shows an arrangement of apparatus for photomicrography with transmitted axial sunlight. To the left is an upright, supporting a horizontal axial tube, with a portion of its upper half cut away to allow an alum or water cell, an ammonio-sulphate of copper cell, a disk of ground glass, and diaphragms, one or more of these, to stand in the lower half. The microscope is seen to the right. Be-

Fig. 38.

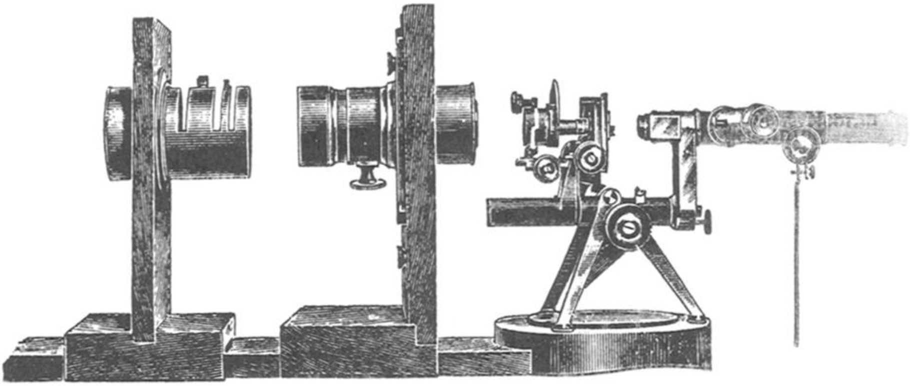
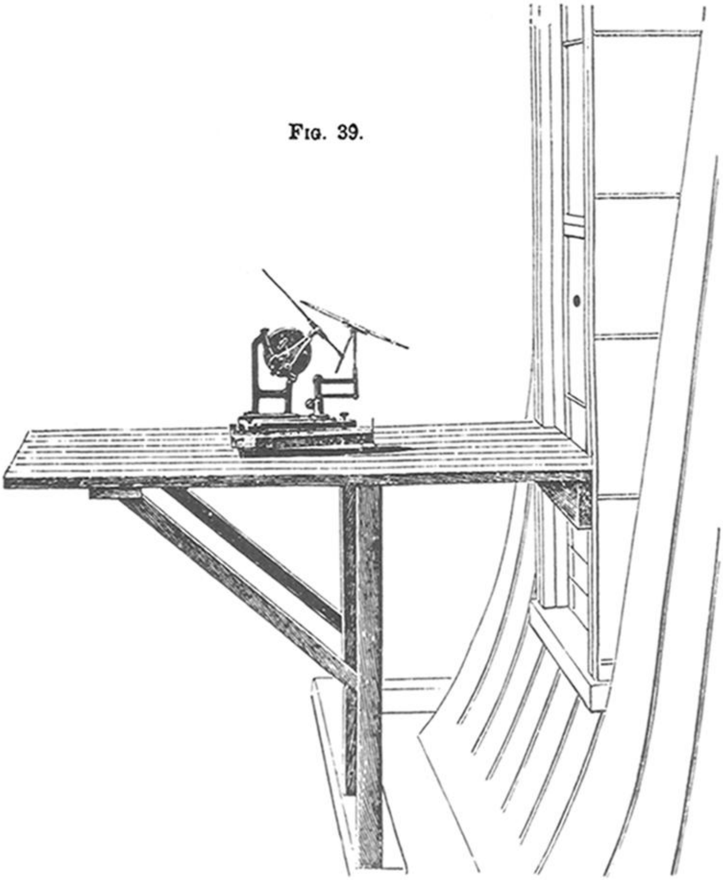


Fig. 39.



tween is an 8-inch portrait lens, so supported by an upright that its distance from the microscope can be varied at pleasure by sliding the upright along the revolving board. The lens is attached to the upright by two sliding boards, one sliding vertically and one horizontally, for the purpose of centering. The portrait lens was originally intended to eliminate diffraction phenomena in accordance with the Woodward method,* but the lens is also occasionally used instead of a substage condenser. Outside a south window, slide 57 (Fig. 39), is a Stratton and Burrill heliostat† on a shelf-table. The window-sash is glazed with plate glass through which the light from the mirror passes without that deterioration which occurs when light passes through the wavy surfaces of an ordinary pane. The place for the heliostat is so marked that it can be within a minute accurately set and levelled over a meridian line cut in the surface of the shelf-table. I have neglected to say previously that the whole apparatus in the room is also accurately placed and levelled over an extension of the same meridian line cut in the floor. By referring to Figs. 35 and 36 it will be seen that the table-top expansion is not directly supported by the three legs. The three legs support a ring into the lumen of which fits nicely but freely a circular plate of hard wood fastened centrally to and below the table-top expansion. This construction permits the camera and microscope to be turned out of meridian while the revolving board remains in meridian for oblique illumination with sunlight. On returning the camera support to the meridian, cleats on the floor stop the instrument in correct position. In photomicrographing opaque objects by sunlight the heliostat is shifted to a meridian one foot to the east, as are also the alum and ammonia-sulphate of copper-cells. The sunlight from the heliostat, after passing through the cells, is received by a long-focus concave mirror and reflected on the opaque object.

A convenience peculiar to the Powell and Lealand, or Ross, model of stand is shown in slides 61 and 62 (not figured). The axial tube is removed and its supporting arm turned to one side. By means of stage forceps various large objects are supported, or on a broad wood superstage a bit of manuscript is flatly fastened, while a short-focus doublet landscape lens on the camera front serves, instead of a microscope objective, to cover a comparatively extensive area and give a perfectly flat field.

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* Monthly Microscopical Journal, vi (1871), p. 170.

† Proc. Am. Soc. Micr., 1885, p. 103.

Exposures are made in a very simple way. While the sensitive plate is being placed, a black card stands close to the ammonio-sulphate of copper cell and intercepts the light. When the plate is in position and all the apparatus satisfactory, the light-intercepting card is removed for the required length of time and then replaced.

In bringing this paper to a close, I wish to acknowledge my indebtedness to Mr. Edward Bausch, of the house of Bausch and Lomb, for practically placing the resources of the firm's great factory at my disposal in the construction of the more special and fine brass-work, so necessary a part of the apparatus.

ERRATA.

In the preface to the preceding volume for 1891, line 6, the date of incorporation should be 1891 in place of 1892, as printed.

On page 144 of current volume the letter C was removed from the plate of Fig. 35 by the engraver; the tube referred to projects from the microscope tube on the further side.